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Determinants of Cashew Agroforestry Adoption Among Smallholder Farmers in the Gambia: Implications for Resilient Farming Systems

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Abstract

Although agroforestry effectively addresses uncertainty, risk, and shocks, its adoption is slow among rural smallholder cashew farmers in the Gambia. This study investigates the factors influencing cashew agroforestry (AF) adoption through a household survey of 250 farmers from seven villages in the Kombo East District, West Coast Region. The adoption determinants were analyzed using a logit regression model and grouped into five categories: a) household preferences, b) resource endowment, c) risk and uncertainty, d) biophysical factors, and e) institutional factors. The study identified 28 factors, including demographics, experience, wealth, environmental threats, awareness, support, and climate change, as significantly influencing AF adoption. Despite recognizing the potential benefits of AF, farmers face constraints such as insufficient funds, poor-quality seedlings, limited extension services, lack of farmland, and low climate awareness. This study's findings offer important insights for addressing the slow adoption of cashew AF in the Kombo East district, with potential relevance for similar regions in the Gambia and beyond. It offers insights for developing policies and programs to promote and accelerate AF adoption, enhance resilience in local farming systems, improve adaptive capacity, and provide diverse livelihood and socioeconomic benefits.

Keywords: *agroforestry adoption, cashew farming, smallholder farmers, logit regression, the Gambia*

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Introduction

As an agrarian economy, the Gambia faces challenges such as low yield, increased poverty, food insecurity, and environmental degradation due to the ineffective traditional fallow system. It results in poor agricultural performance and increased poverty and income inequality, particularly among the rural smallholder farmers. Hence, increasing small-scale agricultural productivity is critical to provide income and employment options as well as to reduce poverty. Agriculture accounts for approximately 17% of the country's gross domestic product (GDP) and 3040% of total export earnings (Niane et al., 2019), employs nearly 46% of the labor force, and provides livelihood to 80% of rural residents. As most Gambians are rural smallholder farmers, they rely heavily on subsistence rain-fed agriculture, making them particularly vulnerable to the impact of climate change (Nyoni et al., 2024). Smallholder farmers have used traditional fallow farming to restore soil fertility. Still, rapid population growth and land usage pressure caused these fallow periods to decrease to levels below what is required for sustainable agriculture (Wanjiku Kamau et al., 2019).

Cashew agroforestry (AF) is perceived as one agricultural technology solution to these compounding problems, as it can provide ecosystem services and bring socioeconomic benefits to the rural smallholder farmers. Cashew AF adoption is crucial in increasing small-scale farmers' incomes, improving food security, and relieving the pressure on forests and communal woods by providing fuelwood, poles, and fodder. Cashew AF adoption is also needed to maintain soil health, sustainably increase productivity, build climate resilience, and reduce greenhouse gas emissions. As AF is the integration of trees into farmlands and agricultural ecosystems, it improves soil quality and health (Dollinger & Jose, 2018), while trees used in AF play a vital role in climate change mitigation by sequestering atmospheric carbon dioxide in soil and plant parts (de Stefano & Jacobson, 2018).

Cashew AF adoption enables cashew production to be an alternative to groundnut production and become another main cash crop for many Gambian farmers. Cashew kernels are a high-value luxury item, with annual sales consistently increasing at 7%, and the market is expected to remain robust. Cashew by-products such as cashew butter, which is made from cracked nuts; cashew nutshell liquid, which may be used for industrial and therapeutic applications; and cashew apple juice, which can be processed further, all have socioeconomic potential. It requires few inputs, and its harvesting does not overlap with other food crops' peak labor demands (Rege & Lee, 2022). Additionally, cashew AF adoption ranges from practices such as cashew alley

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cropping, intercropping, home gardening, live fencing, boundary markers, and woodlots, which are consistent with existing local knowledge and techniques (Toth, 2007). This compatibility may lead to better acceptance by farmers, because these approaches have already been widely practiced and adapted in the Gambia. As a result, cashew AF adoption is now widely promoted as a suitable agricultural technology in the Gambia.

However, cashew AF adoption by rural smallholder farmers in the Gambia has been generally low. Despite all the benefits of cashew AF adoption, there is a lack of understanding of the factors that influence farmers' decision to adopt cashew AF in the Gambia minimally. There is also limited empirical evidence to explain why some farmers practice cashew AF adoption while others do not. Thus, this study investigates the factors influencing the cashew AF adoption by rural smallholder farmers in the Gambia's west coast region. The focus is on the adoption of cashew AF in rural farming practice, which is perceived to be influenced by farmers' socioeconomic and biophysical factors. By understanding these factors, it will provide insight that allows relevant authorities to develop appropriate strategies, policies, and programs for extending, fostering, and promoting cashew AF adoption among small-scale farmers in the region and other similar areas.

Results of this study show that the household preference factor had the greatest influence on cashew AF adoption compared to household resource endowment, the household risk and uncertainty factor, biophysical factors, and market and institutional factors. Socioeconomic factors such as gender, age, education, income, and social status significantly influenced farmers' adoption decisions, thereby aiding in the promotion of sustainable agricultural production, which is critical for the environment and farmers' livelihoods. This study contributes to the literature by identifying socioeconomic and biophysical factors influencing cashew AF adoption. It offers information on socioeconomic and biophysical factors that can aid policymakers in strengthening cashew AF adoption in the Gambia and other similar areas. The study also enriches the climate change literature by addressing climate change adaptation and mitigation in relation to cashew AF adoption, which is relevant for enhancing green production and sustainable agricultural practices.

Conceptual framework on the determinants of agroforestry (AF) adoption AF adoption is a decision-making process where farmers move from awareness to evaluating and ultimately choosing whether to implement cashew AF (Rogers et al., 2014). This process, often shaped by individual perceptions and contextual realities, is influenced by how farmers interpret technologies and assess associated risks and benefits. The conceptual framework, adapted from Mugwe et al. (2009) (Figure 1), reflects this adoption pathway and draws on the innovation-decision model (Rogers et al., 2014). Five key categories were used to analyze determinants of AF adoption: a) household characteristics, b) resource endowment, c) risk and uncertainty, d) biophysical factors, and e) market and institutional factors (Zerihun et al., 2014).

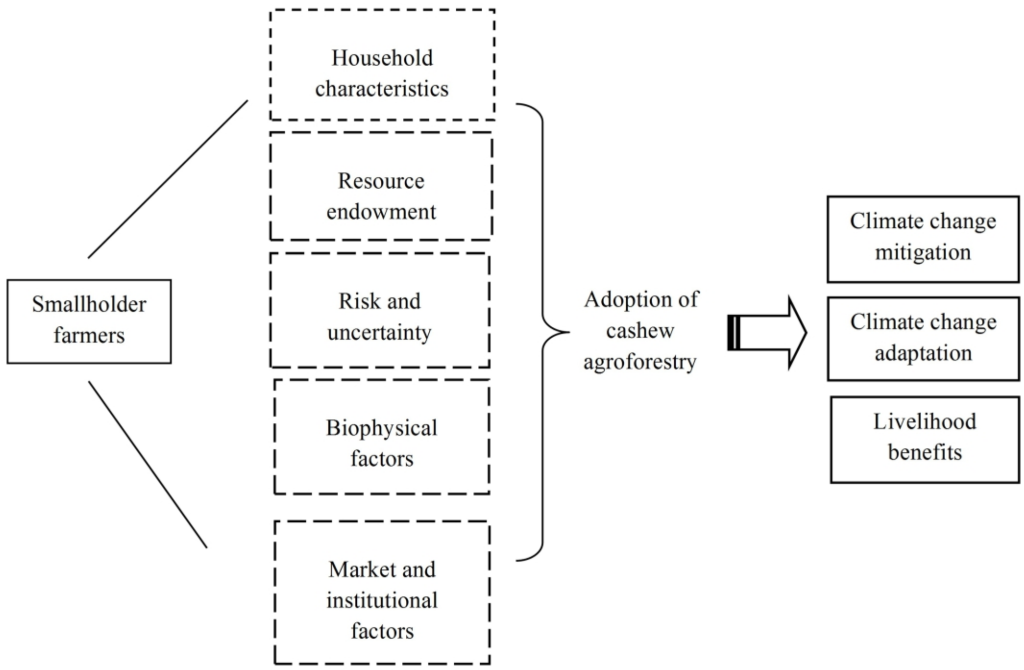

Figure 1 Schematic framework for studying adoption behaviour in cashew agroforestry among smallholder farmer households (Adapted from Mugwe et al., 2009).

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Household characteristics Household characteristics such as gender, age, education, and farming experience shape decisions. Gender roles, particularly male household headship, often determine access to resources and decision-making power (Meinzen-Dick et al., 2019), while women may adopt AF when male counterparts migrate (Jost et al., 2016). Older and less-educated farmers may be more risk-averse or slower to adopt (Tafere & Nigussie, 2018; Ngila et al., 2024), whereas farming experience generally enhances adoption readiness (Sanou et al., 2019).

Resource endowment Resource endowment, including savings and credit, land, livestock, access to finance, farm size, and labor) affects adoption capacity. Larger farms facilitate trials of new systems (Hu et al., 2022; Udimal et al., 2017), while wealth and income allow investment in inputs (Yokamo, 2020). Family size and labor availability are also positively correlated with adoption (Mango et al., 2017; Ruzzante et al., 2021).

Risk and uncertainty Risk and uncertainty elements, such as insecure land tenure, weather variability, and market unpredictability, can deter AF uptake. Ownership security promotes long-term investments (Lawin & Tamini, 2019; Coyne et al., 2021). Information on climate variability and farming experience also shapes adoption behavior (Tambo & Abdoulaye, 2013; Zerihun et al., 2014). Labor demands of AF may limit uptake in labor-scarce areas (Kassa, 2015), though off-farm income may mitigate capital constraints (Jha et al., 2021).

Biophysical factors Biophysical factors, including soil, water supply, and topography, remain central yet underexplored. These influence how farmers assess land suitability and respond to challenges like degradation or water scarcity (Mwase et al., 2015; Apuri et al., 2018; Khan et al., 2021).

Market and institutional factors Market and institutional factors, including access to extension services, credit, and government support, facilitate adoption. Institutional backing, extension outreach, and financing mechanisms have been shown to increase AF uptake (Toth et al., 2019; Norton & Alwang, 2020; Vihi et al., 2019; Läpple et al., 2015).

Methods

Study area The research was conducted in the west coast region of the Gambia. The region comprises an area of 1,764.3 km^2, in which the regional population is about 669,704 with a population density of 397. The sources of livelihood in the area are agroforestry, tourism, livestock, farming, and gardening. Cash earnings are the most common source of income for small-scale farmers in the area, followed by the sale of food crops, profits from small sundry businesses, livestock, charcoal, firewood, and cash crops. The west coast region encompasses nine districts, but the Kombo East district in the Brikama Local Government Area (LGA) was chosen as the study area because of its enormous prospects for agricultural development and cashew production as well as its accessibility.

Preliminary visit and focus group discussion In-depth observation of the study area, including farm walks, was done during the preliminary visit to cashew farms in the Kombo East district. Focus group discussions were conducted afterwards with the local key players in the cashew industry (i.e., local administration, agriculture and forest department staff, traders of agroforestry products, local managers in the private sector, and non-governmental organizations). The focus group discussions were also conducted prior to a pilot study to gather more information and enabled in-depth conversation with the farmers (household heads) regarding their understandings of cashew AF adoption, gaining their insights on the determinants of cashew AF adoption and perspectives about the benefits, shared problems, and other challenges faced by cashew farmers.

Questionnaire design Following the preliminary visit and focus group discussions, a questionnaire was developed and used as the research tool. It consisted of open-ended and closed-ended questions used in the survey interview to gather information about the factors that impact the adoption of cashew AF technologies. Specifically, the questionnaire was designed to collect quantitative information on a) household characteristics, b) resource endowment, c) risk and uncertainty, d) biophysical factors, and e) market and institutional factors. This information is crucial in examining the determinants of cashew AF adoption and exploring fundamental factors influencing farmers' decisions.

Pilot study and data collection A pilot survey tests the questionnaire and helps in improving the questionnaire in terms of identifying relevant content and the suitability of questions used in the questionnaire. It also helps to ensure that the version of the questionnaire used in the final data collection fits the research objectives. For the final data collection, both qualitative and quantitative data were collected from target respondents at seven villages in the Kombo East District (Kafuta, Tumani Tenda, Faraba Banta, Faraba Sutu, Sohm, Basori, and Taneneh). The mode for the pilot study and final data collection was a face-to-face survey interview and was conducted among the selected farm household heads.

Sampling method and sample size This study employed the purposive sampling technique to access a particular subset of people (i.e., farm household heads). The choice of using the purposive sampling technique was also influenced by the need to be on time and to ensure the survey was cost-effective. All survey participants were selected because they fit a particular profile, i.e., working as farmers in agricultural farms and involved in cashew production. The final data collection involved 250 household heads (n: female = 51, male = 199). Although there were originally 265 questionnaires distributed, 15 of them were incomplete and hence excluded from the data compilation, so the response rate of the study is 94%. While purposive sampling was appropriate for targeting cashew-producing farm household heads who were most relevant to the research objectives, this non-probability sampling approach inherently limits the generalizability of the findings. As such, the results should be interpreted with caution and understood as representative of

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the specific study area rather than the broader population of smallholder cashew farmers in the Gambia or other regions.

Empirical model In exploring AF adoption, the logit regression model is utilized, as it allows for a binary output, showing (value 1) if adoption occurred or not (value 0) (Feder & Umali, 1993; Rogers et al., 2014). Logistic regression is a commonly used statistical method in which the likelihood of a dichotomous result (e.g., adoption or non-adoption) is associated with a set of independent variables that are predicted to influence the outcome. The probability of AF adoption can be represented in Equation *[1]*.

$$\text{Logit}\,(Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon_i \qquad [1]$$

note: Y denotes adoption, a dependent dummy variable that indicates the farmer's decision to adopt or not adopt AF, with 1 denoting adopter and 0 denoting non-adopter; $\beta_1, ..., \beta_n$ are the independent variables' coefficients showing the impact of these variables on the likelihood of adoption of AF; and X_1, …, X_{54} are the explanatory variables where Y represents the likelihood of an individual farmer adopting a technology or not; the dependent variable Y = 1 if the household has adopted AF technologies and Y = 0 if the household has not adopted AF technologies.

Farmers are categorized as the adopters if they continued to practice cashew agroforestry, and they are categorized as the non-adopters if they stopped practicing cashew agroforestry. Farmers who practice agroforestry are assigned a value of 1. Those who did not practice agroforestry are assigned a value of 0. The estimated coefficients do not directly reflect the impact of change in the independent variables on the probability of an outcome. The coefficients, on the other hand, reflect the impact of specific independent variables on log (Y) (Zerihun et al., 2014). X is the explanatory variable and represents the regression coefficient of the independent variable, reflecting the probability of adoption of AF. Table 1 is listing all significant predictors and their directions.

Table 1 Summary of significant predictors and its direction

Variables	Predictor variables (Description and measurement unit)	Direction (+/-)
Household head gender	Binary, 1 if the head is male and 0 if female	+
Household head education level	Categorical, level of education	-
Faming experience	Categorical, numbers of years of farming	+
Number of modern roof houses	Discrete, based on observation	-
Social status	Binary, 1 if a farmer has status and 0 if no	=
Annual income	Categorical, amount in Dalasi	+
Months household can afford food	Categorical, numbers of months	+
Afford balanced meal	Likert scale, hardly ever–almost always	=
Family members depending on farm income	Discrete, number depending on farm income	+
Access to financial capital	Binary, 1 if a farmer has access and 0 if no	+
Number of lands owned	Discrete, number of land owned	-
Household size/family labor	Discrete, number of persons	+
Household food secured	Binary, 1 if food is secured and 0 if not food secured	=
Receive remittances	Binary, 1 if yes and 0 if no	-
Household is better off than last year	Binary, 1 if worst off and 0 if better off	+
Soil fertility status	Likert scale, fertile–very unfertile	+
Farm's land slope	Binary, 1 if high slope and 0 if plain	+
Erosion index (in the village)	Likert scale, major problem–not a problem	-
Land degradation (last three years)	Likert scale, not at all–severely degrade	-
Availability of farmlands	Binary, 1 if abundant and 0 if very scarce	_
Climate change awareness	Binary, 1 if yes and 0 if no	+
Importance of livestock income	Likert scale, not important–very important	+
Faced land conflicts	Binary, 1 if yes and 0 if no	-
Changed in rainfall pattern	Likert scale, less rain–more rain	+
Government allocation of land	Binary, 1 if yes and 0 if no	+
Institutional support	Binary, 1 if yes and 0 if no	+
Access to climate information	Binary, 1 if yes and 0 if no	+
Access to seedlings	Binary, 1 if yes and 0 if no	-

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Results

The results of the household survey, which included farmers with an average farm size of 13 ha, showed that among the available agroforestry practices, woodlots (36%), live fencing (16%), orchards or tree gardens (14%), and boundary planting (11%) have higher rates of adoption than alley cropping and intercropping with cashew trees. Alley cropping, intercropping, wind breaks, fodder banks, and fire belts account for 23%. The majority of farmers have traditional cashew farming knowledge, and nearly 92% have been farming cashews for more than 7 years. Of the 250 sample household heads surveyed, 88% had adopted cashew AF, while 12% had not. The average age of the sampled household heads was 35 years, with an average household size of 8.88. To supplement income from cashews, the farmers cultivated the following tree species: mangoes, oranges, lemons, and guavas, all of which are considered food crops and for personal consumption.

Household characteristics The results of the logistic regression of household characteristics variables on cashew AF adoption are summarized in Table 2. Gender was found to have a positive and highly significant effect on cashew AF adoption, indicating that male-headed households are more likely to adopt the practice, likely due to greater access to land, resources, and decision-making authority. The education level of the household head has a negative coefficient at a 1% significance level, suggesting that higher educational attainment may be associated with a lower likelihood of adopting cashew AF, possibly due to a shift in focus toward non-agricultural opportunities or skepticism toward traditional or labor-intensive practices. The number of households with a modern roof, which is a proxy for wealth, has a positive significant coefficient. This data suggests that wealthier households are more likely to adopt cashew AF, likely because they have greater capacity to invest in new technologies, absorb potential risks, and manage the longer-term returns associated with agroforestry systems. The annual household income was a major factor in farmers' decision to adopt cashew AF technology. It was demonstrated by the estimated coefficient being significant at the 1% probability level. Higher-income households are seen to be more capable of financing initial inputs, managing labor requirements, and coping with uncertainties during the establishment phase of cashew AF.

Household resource endowment factors As indicated in Table 3, households with access to financial capital are more likely to adopt cashew AF than those without. This reflects how access to credit or savings can help overcome initial investment barriers commonly associated with agroforestry practices. For the variable of the number of lands owned, it has a negative coefficient but is statistically significant, suggesting that limited land availability constrains households from implementing cashew AF, likely due to the long-term land commitment required for tree planting. Meanwhile, adoption of cashew AF is positive and significantly associated with household size/family labor, indicating that labor availability within the household enhances the likelihood of adopting labor-intensive technologies such as agroforestry. For the household being food secure, it is statistically significant with a negative coefficient at a 1% significance level. This implies that food-secure households are less inclined to change their current farming practices, possibly due to a lower perceived need for adopting alternative systems like cashew AF. Similarly, households that typically receive remittances from abroad are less likely to adopt cashew AF. While these households may appear better off financially, focus group discussions revealed that remittances are generally reserved for consumption or non-farm investments and are not typically allocated for on-farm innovations such as agroforestry. In addition, some farmers perceive cashew AF as requiring considerable labor and long-term commitment, making it less appealing for remittance-receiving households who often prioritize liquidity and flexibility over long-term agricultural investments. By contrast, the estimation for the variable representing better-off households shows a positive and statistically significant coefficient. This suggests that households experiencing improved financial well-beingespecially through agricultural gains rather than external sources–are more inclined to invest in cashew AF. Unlike remittance income, which is externally sourced and often not reinvested in agriculture, improved financial

Table 2 Household characteristics that influence the adoption of cashew AF technologies

Variables	Coefficients	*p*-value	Level of significant
Household head gender	**1.3666450**	**0.002**	***
Household head age	0.1084293	0.410	
Household head education level	**-0.3855813**	**0.001**	***
Faming experience	**0.4371703**	**0.037**	**
Tendency of planting tree	-0.2237392	0.181	
Number of modern roof houses	**-0.5447865**	**0.035**	**
Social status	**-1.5127790**	**0.001**	***
Annual income	**0.3706638**	**0.000**	***
Months household can afford food	**0.992275**	**0.000**	***
Afford balanced meal	**-0.5078115**	**0.002**	***
Family members depending on farm income	**0.5489959**	**0.025**	**
LR chi^2 (11)	81.96		
Prob>chi^2	0.000		
Log likelihood	-52.725		
Pseudo R^2	0.4373		

Note: *** Significant at 1%; ** 5%; * 10%

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Table 3 Household resource endowments that influence the adoption cashew of AF technologies

Variables	Coefficients	*p*-value	Level of significant
Access to financial capital	**1.8987320**	**0.000**	***
Source of land	0.2090558	0.350	
Number of lands owned	**-0.2954770**	**0.010**	**
Income from agriculture	0.0000161	0.178	
Household size/family labor	**0.0725965**	**0.023**	**
Number of livestock owned	0.0286434	0.427	
Off- farm income	-0.3271846	0.141	
Household being food secured	**-1.8495930**	**0.000**	***
Receive remittances	**-1.4895770**	**0.007**	***
Household is better off than last year	**1.6444010**	**0.000**	***
Farm size	-0.0252117	0.765	
LR chi^2 (11)	64.29		
Prob>chi^2	0.000		
Log likelihood	-59.928		
Pseudo R^2	0.3491		

Note: *** Significant at 1%; ** 5%; * 10%

standing from farm-related activities appears to motivate continued or expanded investment in agricultural innovation.

Biophysical factors As shown in Table 4, there are three explanatory variables that represent biophysical factors that are positive and statistically significant. These variables influence household heads towards the adoption of cashew AF technologies. The first variable is the soil fertility status. In the study area, soil fertility is commonly assessed based on the outcomes of previous harvests, reflecting how farmers' own experiences and local knowledge shape their perceptions. Perception-based data, such as this, is often used in similar studies to understand how farmers evaluate their environment, as these perceptions can directly influence agricultural decisions and the likelihood of adopting agroforestry practices. In this case, soil fertility status has a positive coefficient and is statistically significant at the 1% level. The variable for the slope of the farmland has a positive coefficient that is statistically significant. The third variable is climate change awareness, which is a positive coefficient and statistically significant at a 1% level. There are three other variables that are statistically significant but with negative coefficients. The first is the availability of farmland, which is statistically significant at the 1% level. The village erosion index is statistically significant at 5% in the second variable and negatively connected to cashew AF adoption. Finally, the variable of land degradation (last three years) is statistically significant at the 1% level but negatively connected to cashew AF adoption.

Risk and uncertainty factors Regarding risk and uncertainty, the variable representing the importance of livestock income is positive and statistically significant at the 1% level (Table 5). It suggests that households with higher reliance on livestock earnings are more inclined to adopt cashew AF. This may be because livestock income enhances household financial security and diversification, allowing farmers to invest in complementary practices like agroforestry. Land conflict was found to have a negative and significant effect on cashew AF adoption. It implies that insecurity over land ownership or boundaries discourages long-term investments such as tree planting. Since agroforestry requires stable land tenure and a long-time horizon to realize its benefits, households experiencing land disputes may avoid such commitments due to fear of losing access, thus reducing adoption rates. The variable for change in rainfall pattern was positive and statistically significant at the 1% level. Farmers who are aware of climate variability are more likely to adopt cashew AF. Their choice may reflect their recognition of AF's role in climate adaptation, such as mitigating soil erosion, enhancing water retention, and stabilizing yields under erratic weather conditions.

Market and institutional factors Table 6 shows results for the influence of the market and institutional factors on the adoption of AF technology. Only four variables (government land allocation, institutional support, access to climate information, and access to seedlings) are statistically significant. The significance of government land allocation highlights the importance of formal land access in facilitating cashew AF adoption. When land is allocated by the government, it provides a sense of tenure security and legitimacy, which encourages farmers to make long-term investments like planting cashew trees. The statistical significance of institutional support demonstrates that engagement with institutions–such as extension services, NGOs, or farmer organizations–plays a critical role in promoting AF adoption. These institutions often provide technical knowledge, training, and material inputs, which reduce barriers to adoption and increase farmers' confidence in the success of new practices. In addition, the variable for access to climate information is positive and statistically significant at 1%. It indicates that farmers who are better informed about climate change impacts are more likely to adopt cashew AF. This suggests that climate awareness enhances the perceived benefits of agroforestry as a climate-resilient practice. Another statistically significant variable is access to seedlings, which has a negative coefficient. The negative and significant relationship between access to seedlings and cashew AF adoption is counterintuitive but may reflect issues of distribution inefficiency, quality concerns, or a mismatch between supply and actual demand. It is possible that receiving seedlings alone, without adequate support or training, may not translate into successful adoption.

Table 4 Biophysical factors that influence the adoption of cashew AF technologies

Variables	Coefficients	*p*-value	Level of significant
Soil fertility status	**1.7201980**	**0.005**	***
Farm's land slope	**1.6345270**	**0.083**	*
Erosion index (in the village)	**-0.7327263**	**0.048**	**
Land degradation (last three years)	**-1.3679930**	**0.001**	***
Fuel wood scarcity level	-0.1439877	0.817	
Foliage/ grazing land scarcity level	-0.2523011	0.707	
Availability of farmlands	**-1.3864210**	**0.007**	***
Climate change awareness	**1.7102070**	**0.001**	***
Plan to invest to improve or maintain the soil fertility	0.3964449	0.557	
LR chi^2 (9)	70.48		
Prob>chi^2	0.000		
Log likelihood	-58.464		
Pseudo R^2	0.3765		

Note: *** Significant at 1%; ** 5%; * 10%

Table 5 Risk and uncertainty factors that influence the adoption of cashew AF technologies

Variables	Coefficients	*p*-value	Level of significant
Ownership of your farmland	0.0892411	0.919	
Risk attitude	-0.4732936	0.316	
Health status	0.2456227	0.501	
Pace of agricultural technologies adoption	0.0819567	0.918	
Contacts with AF extension agents	0.1728933	0.837	
Membership of farmers' association	-0.3980085	0.450	
Full rights over trees on the farm	0.0047002	0.994	
Importance of livestock income	**0.6684067**	**0.007**	***
Number of hired worker	0.0403904	0.478	
Use of manure on farm	0.3080250	0.523	
Faced land conflicts	**-1.0840710**	**0.068**	*
Changed in rainfall pattern	**1.4088990**	**0.000**	***
LR chi^2 (11)	57.21		
Prob>chi^2	0.000		
Log likelihood	-65.099		
Pseudo R^2	0.3053		

Note: *** Significant at 1%; ** 5%; * 10%

Table 6 Market and institutional factors that influence the adoption of cashew AF technologies

Variables	Coefficients	*p*-value	Level of significant
Market for cashew products	0.1710097	0.709	
Availability of extension services	0.0492834	0.951	
Government allocation of land	**7.032258**	**0.000**	***
Training on agroforestry	-1.000232	0.233	
Involvement in community forest project	0.7709905	0.378	
Institutional support	**1.344043**	**0.000**	***
Access to credit	0.147010	0.892	
Access to climate information	**2.853469**	**0.000**	***
Received public transfer	-0.2715768	0.733	
Access to seedlings	**-0.8160183**	**0.082**	*
LR chi^2 (10)	42.98		
Prob> chi^2	0.000		
Log likelihood	-72.25		
Pseudo R^2	0.2293		

Note: *** Significant at 1%; ** 5%; * 10%

Discussions

Household characteristics Having a male-headed household increases the probability of AF adoption, which is compatible with findings in a study conducted in Malawi, where the more men are predominantly involved in agricultural activity, the more likely the adoption of agroforestry technologies (Coulibaly et al., 2017). Women are generally less likely to adopt AF due to a lack of rights to own property or plant trees on it, as was the case in southwest Tanzania, where women were found to be less likely to practice alley farming (Jha et al., 2021). The fact that male farmers are more likely than female farmers to adopt cashew

AF and its alternatives suggests that more appropriate options for female farmers should be developed to ensure their inclusion in this profitable initiative of cashew AF. This study acknowledges that gender analysis would benefit from an intersectional lens. Based on FGDs, women-headed households often lack secure land tenure, limiting their ability to plant and manage trees. In many cases, they also lack access to extension services or farm support networks, which further constrains their ability to adopt and benefit from agroforestry. These structural barriers, combined with social norms, reduce women's participation even though they represent a significant proportion of the agricultural workforce. Therefore, addressing adoption requires targeted institutional interventions, such as securing land rights and improving outreach for women farmers. Women make up the majority in agriculture, but they face several challenges when implementing sustainable agricultural practices on their farms. To sustain and encourage women participation, gender equity in AF is needed and could be delivered through technology, policy, and institutional interventions.

From the perspective of the education level of household heads, it implies that their education does not influence the adoption of cashew AF technologies in the study area. This result is consistent with Coulibaly et al. (2017), who found that farmers' adoption of fertilizer tree technology in Malawi is unaffected by education level. In fact, the results suggest a negative association between education and AF adoption. In the study area, the negative relationship between the education level of household heads and adoption of AF technologies may be explained by the fact that more educated individuals are less dependent on farming as their main livelihood. FGDs revealed that educated household heads often pursue non-farming occupations or salaried jobs, reducing their interest or time commitment toward long-term agricultural investments like cashew AF. This suggests that higher education does not necessarily align with increased farming innovation, particularly for labor-intensive or long-term systems such as agroforestry. In terms of farmer experiences, a positive coefficient indicates that household heads with accumulated years of experience are more likely to adopt cashew AF technologies. This result is consistent with other studies where farmers' years of experience were also found to influence the adoption of AF practices and climate change mitigation (Oduniyi & Tekana, 2019).

In the case of the number of households with a modern roof (which is a proxy for wealth), the positive and significant coefficient implies that wealthy farmers are more likely to adopt cashew AF technologies than poor farmers. Several previous studies asserted a positive relationship between wealth and the adoption of AF. Meanwhile, the social status factor, often closely associated with wealth, offers an interesting finding. The social status variable, which refers to the relative rank of the household head, decreases the likelihood of adopting cashew AF in the study area. Farmers with higher social status could explain this: they would have a wider social network that could offer other employment opportunities, so they have more chances for getting off-farm jobs and spending less time on farm management.

Their annual household income significantly influenced farmers' decision to adopt cashew AF technology. It was demonstrated by the estimated coefficient of being significant at the 1% probability level; hence if cashew AF adoption can demonstrate its benefits by yielding higher income than the existing practices, its chance of being adopted by farmers could also increase. This result is consistent with the findings of a study conducted in Nigeria, where the annual income of farmers has a significant correlation with the adoption of agroforestry practices (Vihi et al., 2019).

Affording food all year round positively influenced adoption, suggesting that food-secure households are more likely to adopt cashew AF than food-insecure households. This result is in line with the findings of Mugwe et al. (2009), who found that farmers who are food secure for more than three months (in a year) are positively influenced by the adoption of AF practices in Kenya. The study revealed a lower likelihood of cashew AF adoption among households that can afford a balanced meal. The most likely reason is that households with enough food are unlikely to change their farming systems. In the case of family members' dependency on farm income, the variable is positive and statistically significant and thus indicates there is a tendency to adopt cashew AF technology. It indicates that households with more members dependent on farm income are more likely to adopt AF technologies, as it brings more environmental and financial advantages.

Resource endowment As indicated in Table 3, Households that have access to financial capital are more inclined to adopt cashew AF compared to those without such access. The result is similar to a study among the South African farmers (Vihi et al., 2019) and parallel to the finding that households with access to financial capital are found to positively embrace the adoption of the integrated soil fertility management technology (Mponela et al., 2016). Households are less likely to adopt cashew AF due to the limited amount of land owned, as indicated by the negative coefficient (which is statistically significant) for the variable of the number of lands owned. Limited land availability limits the type of technology intended for farming (Mwase et al., 2015); hence cashew AF adoption is hard to implement in the study area because the average amount of land owned by farmers is only two. Household size and family labor are positively and significantly associated with adopting cashew AF. A large family is likely to have a sizable number of farmhands. Because AF is labor-intensive work, the larger the family, the greater the likelihood of adoption (Mwase et al., 2015).

From the perspective of the household being food secure, it is statistically significant with a negative coefficient at the 1% significance level, indicating the households are less likely to adopt cashew AF. This could be explained by the fact that food-secure households are not entirely dependent on farming activity, as they have family members who have better off-farm employment opportunities. Therefore, there is a possibility among the households to continue the same agricultural practice; thus, they are less willing to spend time on taking risks such as changing on-farm activities into cashew AF.

Households that typically receive remittances from

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abroad are less likely to adopt cashew AF. Although households that receive remittances have better finances than those without remittances, these households acknowledged that cashew AF is inherently labor-intensive; thus they are more likely to need to hire extra workers using the remittances. However, FGDs revealed that remittances are generally used for daily consumption or non-farm purposes. As such, the availability of remittances does not necessarily translate into farm-level investment or technology adoption. These households tend to save or spend the funds on immediate needs, which limits their engagement in new farming systems like cashew AF. This reflects a mismatch between financial liquidity and willingness to undertake labor- or time-intensive practices. This evidence corroborates the negative association observed in the model. Meanwhile, for a variable representing a household that is better off than last year, a positive and statistically significant coefficient implies these households are comprised of wealthy farmers that are more likely to adopt cashew AF. Wealthy or well-off families are usually the early adopters of technology, as they are in a better position to take advantage of unproven technologies with unknown futures (Muschler, 2016). For example, household wealth status positively influences adopting climate change and agricultural technology in Nigeria (Tambo & Abdoulaye, 2013).

Biophysical factors As shown in Table 4, if the household believes the land is fertile, it is more likely to adopt cashew AF technologies. In this case, soil fertility status has a positive coefficient and is statistically significant at the 1% level. This result is consistent with the findings of Jha et al. (2021), where soil fertility status significantly affects the adoption of AF by smallholder farmers in Tanzania. For the variable for slope of the farmland, the steeper the slope of the household's farmland, the more likely AF technologies will be adopted. Dawson et al. (2014) found that smallholder households farming on steeper lands are more likely to adopt AF in Mexico because it reduces water flow rate down the slope, thereby reducing soil erosion. Similarly, Zerihun et al. (2014) found that the steeper the slope of household farmlands, the greater the likelihood of adopting AF technologies in South Africa. The other variable is climate change awareness, and the estimation indicates that farmers' awareness of climate change influences their adoption of cashew AF as mitigation and adaptation strategies. This result is compatible with the finding from a study in South Africa, where farmers' adoption of the AF system is significantly affected by their environmental awareness (Oduniyi & Tekana, 2019).

Additionally, the availability of farmland, which is statistically significant at the 1% level, but shows there is a negative association with the adoption of cashew AF, implying that farmers in villages with severe land scarcity are less likely to adopt cashew AF. Since cashew AF compels farmers to set aside a portion of their land for tree planting, the area available for food crops becomes limited. Tree planting may be seen as competing with food crops by farmers in villages with significant land pressure, thereby limiting the possibility of adoption of cashew AF. Farmers in villages with strong land pressure may also not have enough land to adopt agroforestry technology. For example, farmers in Ethiopia, which has very high land pressure and depleted fields, are reluctant to embrace agroforestry innovations (Tafere & Nigussie, 2018). The village erosion index is also statistically significant, but it is negatively connected to cashew AF adoption. This result shows that the probability of farmers adopting cashew AF increases in proportion to the severity of the village's erosion concerns. This is consistent with the findings of Bekele et al. (2024), where the erosion index was reported to be negatively related to the adoption of agroforestry for mitigating land degradation. Finally, while the variable of land degradation (last three years) is statistically significant, it also negatively connected to cashew AF adoption. While land degradation is a major concern for farmers, it is unlikely it will become the priority among the farming community. In the study area, while land degradation is a major issue, most farmers cannot commit their land to long-term cashew agroforestry for crops due to limited land ownership.

Risk and uncertainty factors Regarding risk and uncertainty, the variable representing the importance of livestock income is positive and statistically significant, showing that livestock income increases the likelihood of cashew AF adoption. This result is consistent with the findings of Zerihun et al. (2014), where with a greater number of livestock, there is a greater likelihood for adoption of AF technologies. It was also found that livestock production increased fertilizer tree adoption (Coulibaly et al., 2017), and livestock income influenced farmers' adoption of agroforestry practices (Mwase et al., 2015). In the meantime, land conflict is negative but statistically significant, implying that it reduces the likelihood of cashew AF adoption among farmers in the study areas. This result is consistent with findings by Mugure et al. (2013), where AF practices have not been very successful among Kenyan households due to land ownership issues. Similarly, Toth (2007) discovered that land tenure was one of the most significant barriers to establishing woodlots in Kafuta, a village in the Gambia's western region and one of the villages included in this study. The variable for change in rainfall pattern was also positive and statistically significant, hence indicating that when farmers perceive that rainfall is changing, they are more likely to adopt cashew AF. In a situation where most farmers perceive that rainfall is changing, the farmer will be more likely to plan for potential shocks (Jha et al., 2021). According to a study conducted by Owombo et al. (2018) in Nigeria, farmers are more likely to adopt agroforestry if they perceive it to be a drought-controlling agricultural practice during periods of stagnant rainfall.

Market and institutional factors Results in Table 6 show that the positive coefficient on land allocation by the government indicates that greater support from the government to farmers will increase the likelihood of cashew AF adoption in the study area. Similarly, a positive and significant coefficient of institutional support implies that providing institutional support will significantly increase the likelihood of cashew AF adoption. This conclusion is in line with a study conducted in Uzbekistan, where institutional support has had a positive direct impact on potential participants' decision-making process when adopting agroforestry practices on degraded cropland (Djalilov et al., 2016). The positive and statistically significant coefficient for access to climate information shows that households with access to climate information will greatly incline towards adopting cashew AF. Similarly, having access to climate change information has motivated African cocoa growers to employ agroforestry systems for both food production and climate change mitigation (Arimi & Omoare, 2021). In the case of access to seedlings, the negative coefficient indicates that the availability of seedlings reduces the adoption of cashew AF. This counterintuitive result is explained by findings of this study, where most farmers reported that available seedlings, either self-produced or gifted, were of poor quality. These low-quality seedlings had low survival rates, discouraging further adoption efforts. Most farmers either grow their seedlings or receive them as gifts, rather than accessing grafted or certified planting material. As a result, these seedlings are often not viable, leading to poor establishment and discouraging adoption. This suggests that mere availability of seedlings is not sufficient-quality and technical support are equally critical. Nevertheless, another study, shows in contrast to our findings, that farmers who have a reliable and accessible source of seeds and seedlings are more likely to adopt AF than farmers who do not (Jha et al., 2021).

Conclusion

This study assessed the influence of household preferences, resource endowment, biophysical, risk and uncertainty, and institutional factors on farmers' adoption of cashew AF in Kombo East District, West Coast region of The Gambia, using survey data from 250 household heads and a logit regression model. Results indicate that adoption is encouraged by factors such as household gender, education, farming experience, income, access to financial capital, soil fertility, land characteristics, climate change awareness, government land allocation, and access to climate information, while constraints include land degradation, land scarcity, access to seedlings, and certain household and resource limitations. Ten key variables, i.e., gender of the household head, financial capital access, social status, income, soil fertility, land slope, land degradation, climate change awareness, government land allocation, and access to climate information, emerged as major drivers, highlighting the importance of gender inclusion in agricultural practices. These findings provide critical insights for policymakers and stakeholders to design targeted interventions that enhance cashew AF adoption, improve farm productivity, and deliver long-term socio-economic and environmental benefits in the West Coast Region.

Policy implications

The results of this study provide clear insights into the factors influencing cashew agroforestry (AF) adoption in the Kombo East District, West Coast Region of the Gambia. Based on these findings, the following policy recommendations are proposed:

1. Promote gender-inclusive approaches: Gender was found to significantly influence the adoption of cashew AF. Policies should aim to involve both male and female household heads in AF adoption programs. By ensuring equal access to resources and training for both genders, these initiatives can foster better knowledge sharing and skill integration, leading to improved farm productivity and household well-being.
2. Enhance access to financial capital: Access to financial resources is a critical driver of cashew AF adoption. To support farmers, especially those from lower-income households, policies should focus on improving access to financial capital through low-interest loans, subsidies, or microfinance programs. This will enable farmers to invest in the necessary resources, such as quality seedlings and tools, for successful cashew AF implementation.
3. Improve access to land and climate information: Farmers who had access to climate information were more likely to adopt cashew AF. To support wider adoption, the government and NGOs should prioritize agricultural extension services that provide farmers with reliable climate data and guidance on climate-resilient practices. Additionally, clear land tenure policies and government land allocation can provide security and incentivize farmers to invest in agroforestry.
4. Focus on soil health and land management: Soil fertility and land degradation were found to be significant factors in adoption. Policies should promote sustainable land management practices that enhance soil fertility and prevent degradation. Providing farmers with training on soil conservation and agroecological techniques can improve land productivity and make cashew AF more sustainable.
5. Encourage climate change adaptation: Awareness of climate change positively influenced cashew AF adoption. Policymakers should continue to support climate adaptation strategies, such as providing incentives for climate-smart farming practices. Farmers should be encouraged to adopt practices that improve resilience to climate variability, such as water conservation methods and agroforestry diversification.
6. Strengthen institutional support and seedling access: Institutional support and access to quality seedlings were key enablers of AF adoption. Governments and NGOs should collaborate to ensure farmers have access to high-quality seedlings and continuous technical support. Strengthening local agricultural institutions and providing platforms for farmer knowledge exchange will further support adoption efforts.
7. Support farm diversification: The study revealed that farmers diversify their income sources through other food crops and livestock. Policies should encourage this diversification by supporting smallholder farmers with resources and training on how to integrate various crops and livestock into their agroforestry systems, which can lead to greater income stability.
8. Resolve land conflicts: The presence of land conflicts negatively affected AF adoption. Policies should prioritize resolving land tenure disputes and securing clear land rights for farmers. Ensuring that farmers have

stable land tenure will encourage long-term investment in agroforestry practices and improve their livelihoods.

These policy implications, directly drawn from the study's findings, can guide government and institutional efforts to support and enhance the adoption of cashew agroforestry in the Gambia and areas of similar contexts. By addressing the key factors identified in the study, these policies can foster sustainable agricultural practices and improve farmers' socio-economic conditions.

Recommendation

These findings provide evidence for countries with similar economies reliant on agriculture and natural resources, such as forestry. They highlight the importance of incorporating cashew AF into community forest programs. Cashew AF can be integrated into government green growth initiatives to support climate change adaptation and improve rural livelihoods. Governments should consider incentivizing farmers to adopt cashew AF to enhance carbon sequestration and reduce emissions. Based on this study's findings and the economic importance of cashews, a focused research effort to improve nut quality and productivity per land area is critical. Increasing the availability of grafted cashew seedlings from high-yielding varieties could encourage adoption in the West Coast region and nationwide. Additionally, extension services should provide training on tree management practices, such as pruning and trimming, to minimize negative ecological impacts on the farming system. Implementing these practical measures will accelerate cashew AF adoption and contribute to sustainable agricultural development, climate change mitigation, and improved rural livelihoods. Achieving these outcomes requires collaboration among policymakers, researchers, extension agents, and farmers to ensure the resilience and sustainability of the agricultural sector.

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References

Apuri, I., Peprah, K., & Achana, G. T. W. (2018). Climate change adaptation through agroforestry: The case of Kassena Nankana West District, Ghana. *Environmental Development*, *28*, 32–41. https://doi.org/10.1016/j.envdev.2018.09.002

Arimi, K., & Omoare, A. (2021). Motivating cocoa farmers to adopt agroforestry practices for mitigating climate change. *Renewable Agriculture and Food Systems*, *36*(6), 599–604. https://doi.org/10.1017/S174217052 1000223

Bekele, E., Abera, G., & Temesgen, H. (2024). Adoption and intensity influencing factors of agroforestry systems for mitigating land degradation (MLD) in Gilgel Gibe I catchment, southwestern Ethiopia. *Cogent Food and Agriculture*, *10*(1), Article 2380782. https://doi.org/10.1080/23311932.2024.2380782

Coulibaly, J. Y., Chiputwa, B., Nakelse, T., & Kundhlande, G. (2017). Adoption of agroforestry and the impact on household food security among farmers in Malawi. *Agricultural Systems*, *155*, 52–69. https://doi.org/10.1016/j.agsy.2017.03.017

Coyne, L., Kendall, H., Hansda, R., Reed, M. S., & Williams, D. J. L. (2021). Identifying economic and societal drivers of engagement in agri-environmental schemes for English dairy producers. *Land Use Policy*, *101*, Article 105174.

Dawson, I. K., Leakey, R., Clement, C. R., Weber, J. C., Cornelius, J. P., Roshetko, J. M., Vinceti, B., Kalinganire, A., Tchoundjeu, Z., Masters, E., & Jamnadass, R. (2014). The management of tree genetic resources and the livelihoods of rural communities in the tropics: Non-timber forest products, smallholder agroforestry practices and tree commodity crops. *Forest Ecology and Management*, *333*, 9–21. https://doi.org/10.1016/j.foreco.2014.01.021

de Stefano, A., & Jacobson, M. G. (2018). Soil carbon sequestration in agroforestry systems: A meta-analysis. *Agroforestry Systems*, *92*, 285–299. https://doi.org/10.1007/s10457-017-0147-9

Djalilov, B. M., Khamzina, A., Hornidge, A. K., & Lamers, J. P. (2016). Exploring constraints and incentives for the adoption of agroforestry practices on degraded cropland in Uzbekistan. *Journal of Environmental Planning and Management*, *59*(1), 142–162. https://doi.org/10.1080/09640568.2014.996283

Dollinger, J., & Jose, S. (2018). Agroforestry for soil health. *Agroforestry Systems*, *92*, 213–219. https://doi.org/10.1007/s10457-018-0223-9

Feder, G., & Umali, D. L. (1993). The adoption of agricultural innovations: A review. *Technological Forecasting and Social Change*, *43*(34), 215–239. https://doi.org/10.1016/0040-1625(93)90053-A

Hu, Y., Li, B., Zhang, Z., & Wang, J. (2022). Farm size and agricultural technology progress: Evidence from China. *Journal of Rural Studies*, *93*, 417–429. https://doi.org/10.1016/j.jrurstud.2019.01.009

Jha, S., Kaechele, H., & Sieber, S. (2021). Factors influencing the adoption of agroforestry by smallholder farmer households in Tanzania: Case studies from Morogoro and Dodoma. *Land Use Policy*, *103*, Article 105308. https://doi.org/10.1016/j.landusepol.2021.105308

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bisrom, M. -L., Nelson, S., & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, *8*(2), 133–144. https://doi.org/10.1080/17565529.2015.1050978

Kassa, G. (2015). Profitability analysis and determinants of fruit tree based agroforestry system in Wondo District, Ethiopia. *African Journal of Agricultural Research*, *10*(11), 1273–1280. https://doi.org/10.5897/AJAR2014.9272

Khan, A. U., Choudhury, M. A. R., Maleque, M. A., Dash, C. K., Talucder, M. S. A., Maukeeb, A. R. M., Ema, I. J., & Adnan, M. (2021). Management of insect pests and diseases of jackfruit (*Artocarpus heterophyllus* L.) in agroforestry system: A review. *Acta Entomology and Zoology*, *2*(1), 37–46. https://doi.org/10.33545/27080013.2021.v2.i1a.29

Läpple, D., Renwick, A., & Thorne, F. (2015). Measuring and understanding the drivers of agricultural innovation: Evidence from Ireland. *Food Policy*, *51*, 1–8. https://doi.org/10.1016/j.foodpol.2014.11.003

Lawin, K. G., & Tamini, L. D. (2019). Land tenure differences and adoption of agri-environmental practices: Evidence from Benin. *The Journal of Development Studies*, *55*(2), 177–190. https://doi.org/10.1080/00220388.2018.1443210

Mango, N., Makate, C., Tamene, L., Mponela, P., & Ndengu, G. (2017). Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. *International Soil and Water Conservation Research*, *5*(2), 122–129. https://doi.org/10.1016/j.iswcr.2017.04.003

Meinzen-Dick, R., Quisumbing, A., Doss, C., & Theis, S. (2019). Women's land rights as a pathway to poverty reduction: Framework and review of available evidence. *Agricultural Systems*, *172*, 72–82. https://doi.org/10.1016/j.agsy.2017.10.009

Mponela, P., Tamene, L., Ndengu, G., Magreta, R., Kihara, J., & Mango, N. (2016). Determinants of integrated soil fertility management technologies adoption by smallholder farmers in the Chinyanja Triangle of Southern Africa. *Land Use Policy*, *59*, 38–48. https://doi.org/10.1016/j.landusepol.2016.08.029

Mugure, A., Oino, P. G., & Sorre, B. M. (2013). Land ownership and its impact on adoption of agroforestry practices among rural households in Kenya: A case of Busia county. *International Journal of Innovation and Applied Studies*, *4*(3), 552–559.

Mugwe, J., Mugendi, D., Mucheru-Muna, M., Merckx, R., Chianu, J., & Vanlauwe, B. (2009). Determinants of the decision to adopt integrated soil fertility management practices by smallholder farmers in the central highlands of Kenya. *Experimental Agriculture*, *45*(1), 61–75. https://doi.org/10.1017/S0014479708007072

Muschler, R. G. (2016). Agroforestry: Essential for sustainable and climate-smart land use. *Tropical Forestry hHandbook*, *2*, 2013–2116. https://doi.org/10.1007/978-3-642-54601-3_300

Mwase, W., Sefasi, A., Njoloma, J., Nyoka, B. I., Manduwa, D., & Nyaika, J. (2015). Factors affecting adoption of agroforestry and evergreen agriculture in Southern Africa. *Environment and Natural Resources Research*, *5*(2), Article 148. https://doi.org/10.5539/enrr.v5n2p148

Ngila, V. M., Kweyu, R. M., & Mbuthia, S. W. (2024). Socio-economic drivers of agroforestry practices in Kaiti Watershed, Makueni County, Kenya. East African *Journal of Forestry and Agroforestry*, *7*(1), 200–214. https://doi.org/10.37284/eajfa.7.1.1957

Niane, A. F. N., Kini, R., Salau, S., & Chaherli, N. M. (2019). *The Gambia agriculture engagement note: Fostering agriculture-led inclusive growth*. Washington: World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/814691560411931505

Norton, G. W., & Alwang, J. (2020). Changes in agricultural extension and implications for farmer adoption of new practices. *Applied Economic Perspectives and Policy*, *42*(1), 8–20. https://doi.org/10.1002/aepp.13008

Nyoni, R. S., Bruelle, G., Chikowo, R., & Andrieu, N. (2024). Targeting smallholder farmers for climate information services adoption in Africa: A systematic literature review. *Climate Services*, *34*, Article 100450. https://doi.org/10.1016/j.cliser.2024.100450

Oduniyi, O. S., & Tekana, S. S. (2019). Adoption of agroforestry practices and climate change mitigation strategies in North West province of South Africa. *International Journal of Climate Change Strategies and Management*, *11*(5), 716–729. https://doi.org/10.1108/IJCCSM-02-2019-0009

Owombo, P. T., Idumah, F. O., & Adepoju, A. O. (2018). Analysis of farmers' perception and adoption of agroforestry technology as climate change mitigation strategy in Edo State, Nigeria. *World News of Natural Sciences*, *21*, 16–27.

Rege, A., & Lee, J. S. H. (2022). State-led agricultural subsidies drive monoculture cultivar cashew expansion in northern Western Ghats, India. *PLoS ONE*, *17*, Article 0269092. https://doi.org/10.1371/journal.pone.0269092

Rogers, E. M., Singhal, A., & Quinlan, M. M. (2014). Diffusion of innovations. In *An integrated approach to communication theory and research* (pp. 432–448). Routledge.

Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of

Jurnal Manajemen Hutan Tropika, *31*(3), 229–241, September 2025
EISSN: 2089-2063
DOI: 10.7226/jtfm.31.3.229

ISSN: 2087-0469

agricultural technology in the developing world: A meta-analysis of the empirical literature. *World Development*, *146*, Article 105599. https://doi.org/10.1016/j.worlddev.2021.105599

Sanou, L., Savadogo, P., Ezebilo, E. E., & Thiombiano, A. (2019). Drivers of farmers' decisions to adopt agroforestry: Evidence from the Sudanian savanna zone, Burkina Faso. *Renewable Agriculture and Food Systems*, *34*(2), 116–133. https://doi.org/10.1017/S1742170517000369

Tafere, S. M., & Nigussie, Z. A. (2018). The adoption of introduced agroforestry innovations: Determinants of a high adoption rate–a case-study from Ethiopia. *Forests Trees and Livelihoods*, *27*(3), 175–194. https://doi.org/10.1080/14728028.2018.1493954

Tambo, J. A., & Abdoulaye, T. (2013). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Regional Environmental Change*, *13*(2), 375–388. https://doi.org/10.1007/s10113-012-0351-0

Toth, J. M. (2007). Assessment of potential agroforestry systems for Kafuta: A village in the Western Division of the Gambia [theses]. Missoula: The University of Montana. Retrieved from https://scholarworks.umt.edu/etd/76

Toth, G. G., Nair, P. K. R., Jacobson, M., Widyaningsih, Y., & Duffy, C. P. (2019). Malawi's energy needs and agroforestry: Impact of woodlots on fuelwood sales. *Energy for Sustainable Development*, *50*, 101–108. https://doi.org/10.1016/j.esd.2019.02.006

Udimal, T. B., Jincai, Z. Mensah, O. S., & Caesar, A. E. (2017). Factors influencing the agricultural technology adoption: The case of improved rice varieties (Nerica) in the Northern Region, Ghana. *Journal of Economics and Sustainable Development*, *8*(8), 137–148.

Vihi, S. K., Adedire, O., & Ngu-Uma, B. K. (2019). Adoption of agroforestry practices among farmers in gwaram local government area of Jigawa State, Nigeria. Asian *Journal of Research in Agriculture and Forestry*, *4*(4), 1–13. https://doi.org/10.9734/ajraf/2019/v4i430069

Wanjiku Kamau, J., Biber-Freudenberger, L., Lamers, J. P. A., Stellmacher, T., & Borgemeister, C. (2019). Soil fertility and biodiversity on organic and conventional smallholder farms in Kenya. *Applied Soil Ecology*, *134*, 85–97. https://doi.org/10.1016/j.apsoil.2018.10.020

Yokamo, S. (2020). Adoption of improved agricultural technologies in developing countries: Literature review. *International Journal of Food Science and Agriculture*, *4*(2), 183–190. https://doi.org/10.26855/ijfsa.2020.06.010

Zerihun, M. F., Muchie, M., & Worku, Z. (2014). Determinants of agroforestry technology adoption in Eastern Cape Province, South Africa. Development Studies Research. *An Open Access Journal*, *1*(1), 382–394. https://doi.org/10.1080/21665095.2014.977454